

Novel Supercomputing Approaches for High Performance Linear Algebra Using FPGAs, Phase I

Completed Technology Project (2007 - 2007)



Project Introduction

We propose to develop novel FPGA-based algorithmic technology that will enable unprecedented computational power for the solution of large sparse linear equation systems. In Phase I, we will develop a prototype of a non-von-Neumann linear equation solver equipped with our technology, and demonstrate an intermediate milestone for its operational speedup and performance gains using at least two of the CFD problems in the NAS benchmark. Phase I will also deliver a clear technology roadmap in terms of algorithmic and architectural innovations needed to bring the project to success by the end of Phase II. Four mission-critical areas to the success of an FPGA-based non-von-Neuman system within a von-Neumann-based supercomputing environment are identified, namely (1) portability; (2) ease of use; (3) algorithmic speed balance between von-Neumann and non-von-Neumann components; and (4) communication speed. Innovative architectural and algorithmic methods aimed at boosting system effectiveness through each one of the four areas are proposed. In particular, we propose the use of "portability wrappers" to enable wide portability at both hardware and software levels, software drivers in the form of an API for ease of use from a C and/or Fortran environment, innovative reconfigurable computing algorithms and bit structure optimizations suited to the LU factorization problem for speed, and a novel algorithmic technique within the reconfigurable computing paradigm that effectively eliminates the communication bottleneck, typical of multi-system distributed algorithms, for the LU factorization problem. The performance attainable with a single FPGA will be comparable to that of a 1,000-node commodity cluster, while exhibiting reductions of one to two orders of magnitude in both cost and power consumption.

Anticipated Benefits

aerospace and automotive industries, computational fluid dynamics (CFD), defense, digital content creation, digital media, electronics, energy, finance, economic and financial forecasting, computational chemistry, molecular biology, computational physics, civil engineering, environmental engineering, gaming, geophysics, image processing, information processing services, life sciences, media, medicine, semiconductors, telecommunications, weather and climate research, weather forecasting, etc. aerospace system design, weather prediction, space and earth imagery analysis, computational fluid dynamics (CFD), computational physics, information processing systems, climate research, Computational Materials, Computer System Architectures, Data Input/Output Devices, Software Tools for Distributed Analysis and Simulation, Structural Modeling and Tools etc.



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Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Ames Research Center (ARC)

Responsible Program:

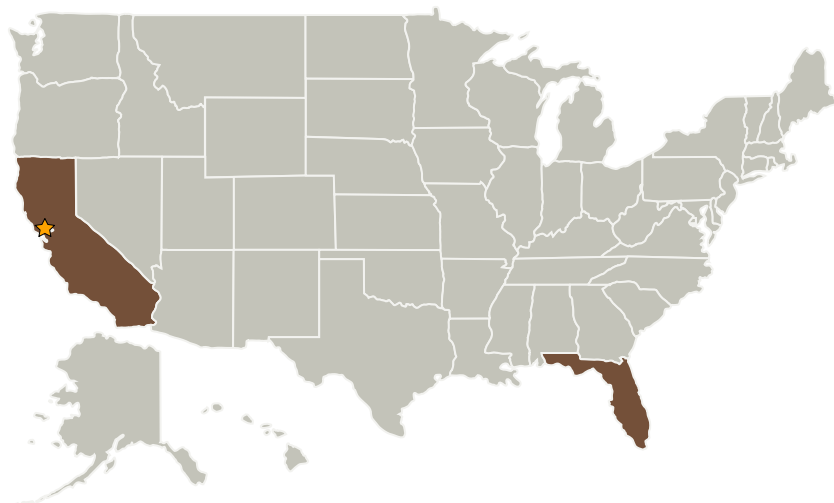
Small Business Innovation Research/Small Business Tech Transfer

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Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★ Ames Research Center(ARC)	Lead Organization	NASA Center	Moffett Field, California
Accellogic, LLC	Supporting Organization	Industry	Weston, Florida

Primary U.S. Work Locations

California	Florida
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Project Management

Program Director:

Jason L Kessler

Program Manager:

Carlos Torrez

Project Manager:

Guru P Guruswamy

Principal Investigator:

Juan Gonzalez

Technology Areas

Primary:

- TX15 Flight Vehicle Systems
 - TX15.1 Aerosciences
 - TX15.1.3 Aeroelasticity